Renewables Overview

Opportunities for Renewables Workshop
Honolulu, Hawaii
April 2, 2001

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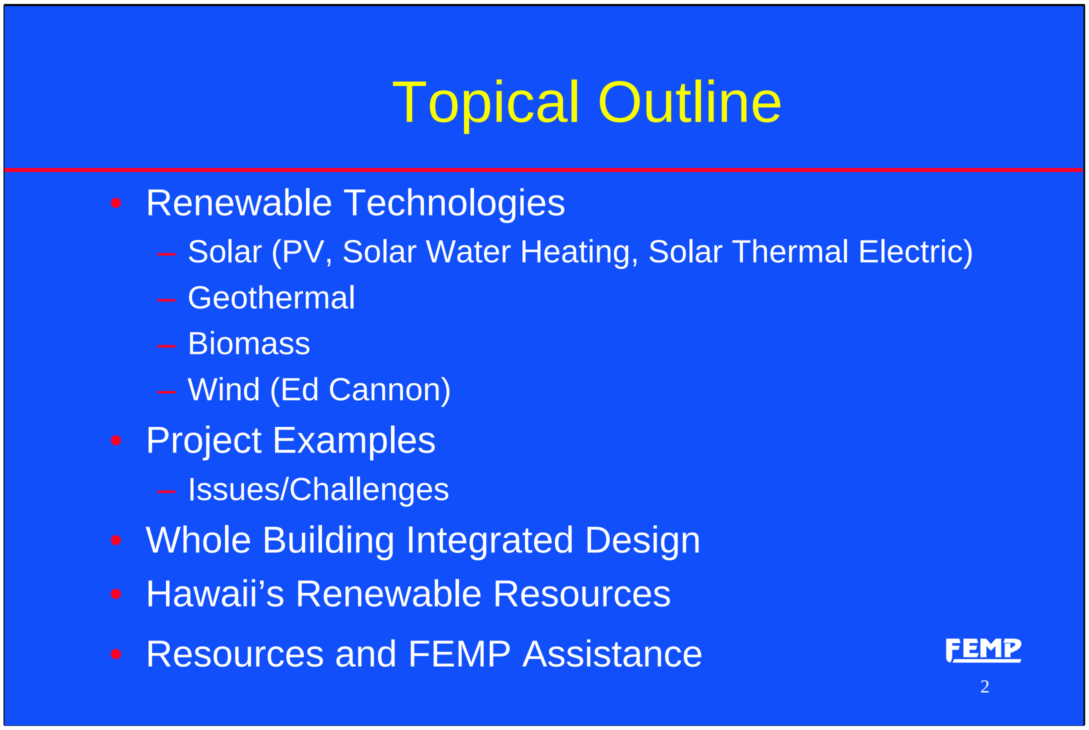

PV and SWH are usually on-site/distributed

Solar Thermal Electric - usually centralized power stations

Wind will be covered by Ed Cannon later today

WBID - also known as sustainable design, low energy design

Energy Efficiency First

Every watt not used is a watt that doesn't have to be produced, processed, or stored.

Richard Perez, 1991

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Photovoltaics

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What are Photovoltaics (PV)?

- PV - Use semiconductor material to convert sunlight directly to electricity
- Building-Integrated Photovoltaics (BIPV) - Systems where PV elements are integral part of the building

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Photoelectric Effect - PV uses certain semiconductor materials which release electrons when hit by photons of energy from the sun.

Can use direct and reflected/diffuse light

BIPV - part of roof, wall, skylight, other element

Types of Arrays

Fixed

Remote

Building-integrated

Tracking

single axis

double axis

PV Technologies

- Crystalline Silicon
- Thin Film
  - Approximately 50 times thinner
  - Material mounted onto an inexpensive backing
  - Easier to manufacture
  - Less efficient

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Efficiency - amount of total sunlight energy converted to electricity

-PV today around 10%

Material used - cadmium, copper, indium, gallium, selenium, tellurium

Thin film - multi-crystalline (vs. single crystal) or amorphous (non-crystalline) silicon

From NREL **8/98** fact sheet

-NREL World Record - Gallium Indium Phosphide/Gallium Arsenide 29.5%

-NREL World Record (thin film) - Copper Indium Gallium Diselenide 17.7%

NREL Research

-Different materials

-increased efficiency

-reduced manufacturing costs

-Increased reliability - what causes system failure?

-Test under various, extreme weather conditions - heat, cold, humidity/moisture, snow, hail

-increased over-all performance

PV "Balance of System" Components

- ***Inverter*** - convert direct current (DC) to alternating current (AC)
- ***Batteries*** - store charge for when it is needed
- ***Battery Charge Controller*** - protect battery from over-charging
- ***Low Voltage Disconnect*** - protect battery from over-discharging
- ***Other*** - Safety disconnects and fuses, grounding circuit, wiring, combiner boxes,
- ***Automatic Generator Starter/Stopper*** - start a generator when battery is too low.

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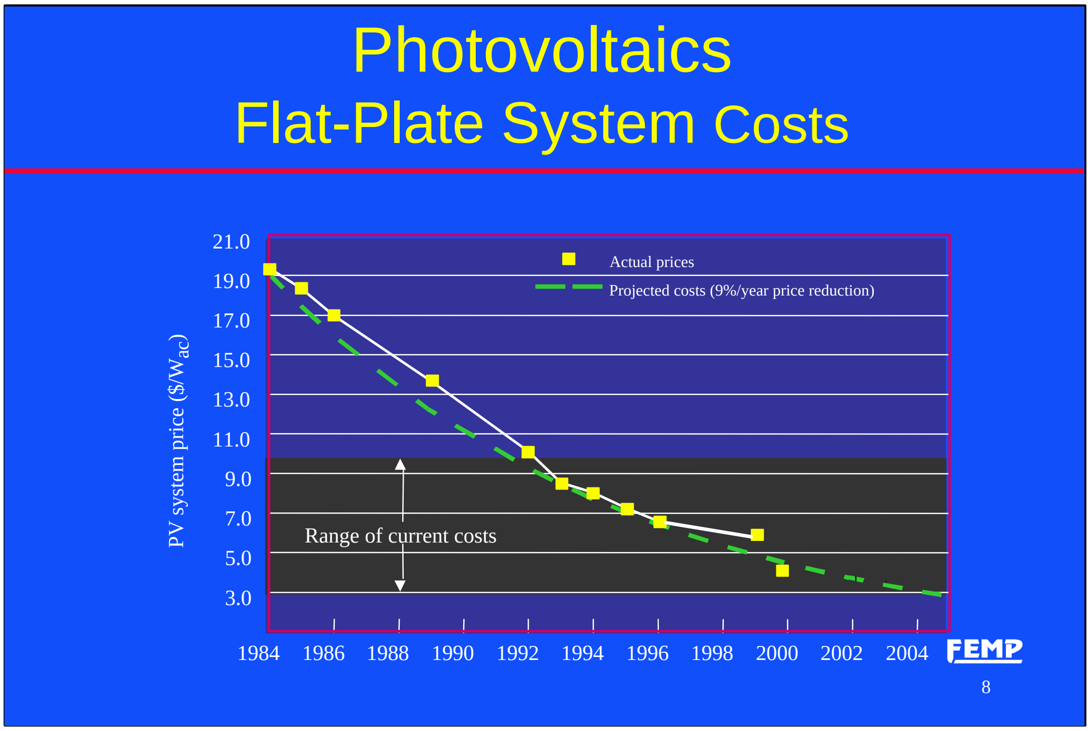

Costs

\$/watt$_{ac}$ = Alternating Current. Includes inverter. Average costs for variety of systems.

\$3/watt by 2005 (or about 12 cents/kWh)
10 cents/kWh by 2010.
SMUD reached \$4.50/watt before incentives in 2000. (see single square)

Typically on-site --> competes with retail prices (not wholesale)

Market Trends

U.S. photovoltaic production has expanded 21% per year - on average - for the last 12 years. In 1997, 73% of U.S. photovoltaic production was shipped overseas. (REA 1998/EIA)

Cost Effective PV Applications

- Remote/Off-Grid Applications
  - Avoid Line Extensions ($20k to $100k/mile)
  - Replace Expensive Diesel Generators
- Other - street/parking lights, highway signs, emergency call boxes, water pumping, irrigation controls, navigation buoys, satellites, communications stations, calculators, PV covered carports for electric car recharging
- Hawaii Break-Even Turnkey Cost = $6-$10/watt.
  - One of the best locations in the nation for solar!

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Diesel cost - $0.20 (Guam, LARGE generator system) to $1.70/kWh (Colorado state park, SMALL, 7 kw system)

Irrigation - if utility interconnection involves crossing streets and digging trenches, PV can be competitive

Destroy hazardous contaminants

Hawaii Federal Projects

Humpback Whale Sanctuary (Maui) - first PV grid-connected system in Hawaii

PJKK Federal Building

Smithsonian Astrophysical Observatory, Hilo - BIPV proposed

Benefits of PV

- Low operating costs - no fuel requirements and associated price risk volatility
- May be the lowest cost option
- Max. power usually coincident with peak demand
- Portable
- Reliable source of power after storms
- Abundant, indigenous resource
- No (or few) moving parts --> minimal maintenance
- Noise and pollution free
- Modular

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Show PV Disaster brochure

Modular - can be constructed to meet any size req't

Easily enlarged if needed to meet increased demand

PJKK Federal Building, HI
PV Lighting

- DC (no inverter needed)
- 2 solar panels per lamp with peak output of 96 watts
- 39 Watt fluorescent lamps, 2500 lumens
- 90 amp-hour battery powers 12 hours per night
- ~$2500 per light

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Mauna Lani Hotel
BIPV

- PowerGuard ® insulated roof tiles with photovoltaics
- 10,000 sq. ft. area
- 75 kW capacity
- Rate of return over 20%

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•payback in 5 years

* Project financing through Power Light

Natatorium Swimming Facility

1996 Summer Olympics - Atlanta, GA

- World's largest Building Integrated Roof-Top PV system (340 kW).
- Solarex Corporation PV Modules
- Cost-Shared evenly between DOE, Georgia Institute of Technology and Georgia Power.

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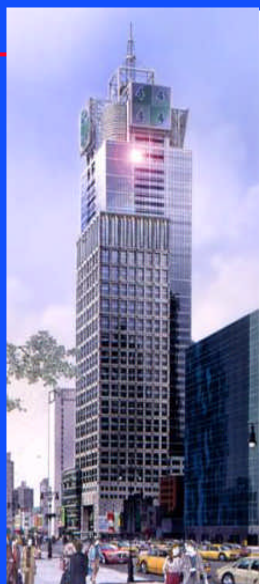
4 Times Square, NY City

Broadway & 42nd Street



- Thin-Film PV replaces traditional glass cladding material.
- PV Curtain Wall extends from 38th to 45th floor, on south and east walls.
- PV Modules: Energy Photovoltaics (Princeton, NJ)
- Developer: Durst Organization
- Architects: Kiss + Cathcart, Fox and Fowle

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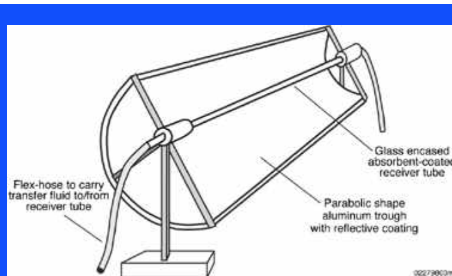
Solar Water Heating

Solar Water Heating Technologies



- Energy from the sun heats water as it passes through the collector
- Variety of collectors and systems

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Large, flat boxes with one or more glass covers to trap heat inside.
-Usually insulated to keep heat in.
-Inside box are dark covered plates that absorb heat and transfer it to water, air or other working fluid in the tubes.

If sunlight not available, backup gas or electric water heater kicks in

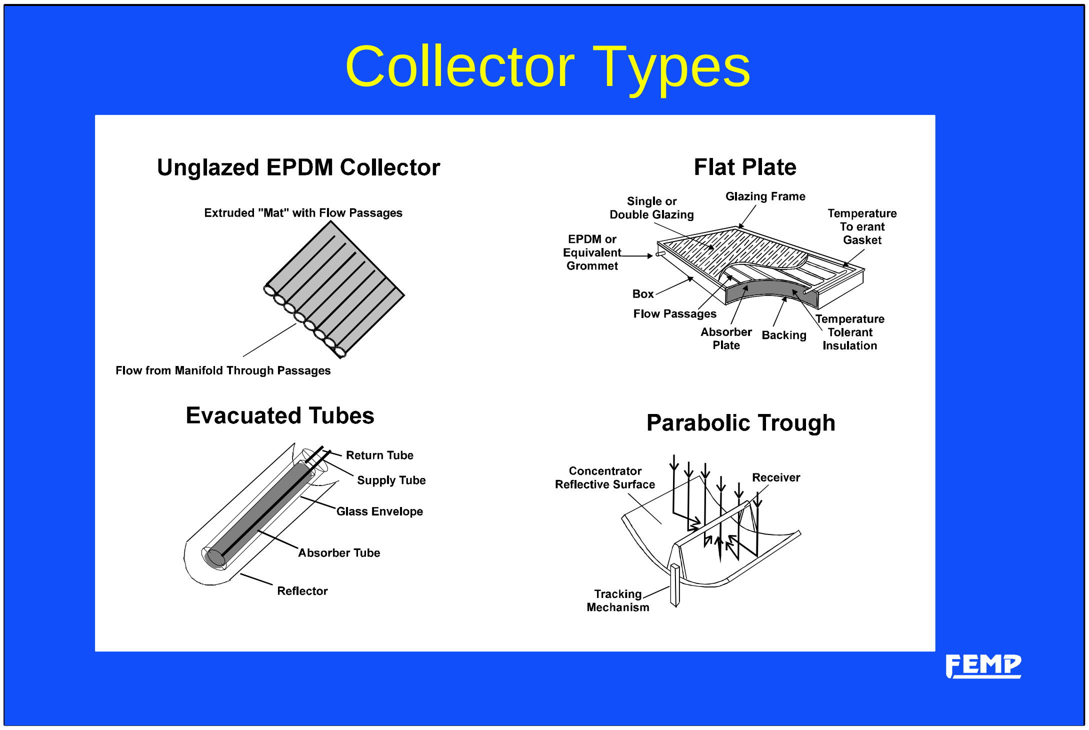
Freeze protection
 - drain-back or drain-down.
-Antifreeze loop through collector

SHW Improvements

lower capital costs

stronger, lighter, more durable material

Better total system reliability, maintainabaility and user-friendliness



Solar thermal collectors can be categorized by the temperature at which they efficiently deliver heat.

EPDM - something to do with rubber.

Low-temperature collectors (0-10 C above ambient) -

Unglazed EPDM Collector

Unglazed mats for water heating. (swimming pools)

-plastic absorber with extruded flow passages.

Perforated plates for air preheating (Solar Wall)

Mid-temperature collectors (10-50 C above ambient): - Flat Plate **:**

Glazed and insulated collectors.

-works well in humid climates where sunlight is more hazy and diffuse

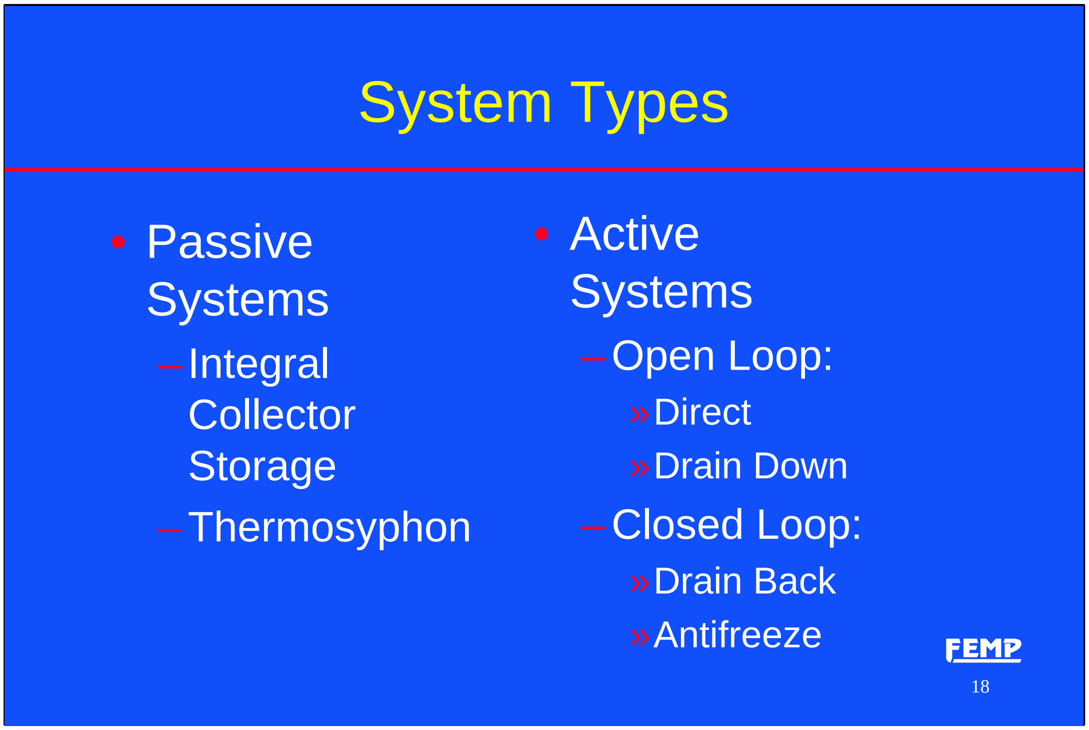
High-temperature collectors (>50 C above ambient):

Evacuated tubes. Less heat loss. Industrial processes

Focusing collectors (tracks the sun. requires direct, not diffuse light).

Parabolic Trough - High T. Less heat loss. Industrial processes. Could be low Temp up to 400 F

Parabolic troughs also used for electricity generation.



* **Active** - use pumps or fans to move heat-transfer fluids from collectors to storage tanks.

* **Passive**:- operate without pumps and controls. Use design features and (**natural ventilation??)**

-can be more reliable, more durable, easier to maintain, longer lasting, and less expensive to operate than active systems.

-should be used only in warm, sun-belt climates

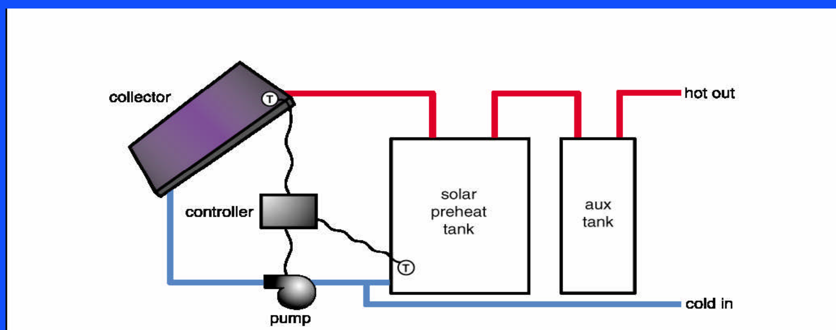
* **Indirect/closed loop** - use a fluid with a low freezing point (such as propylene glycol) in the collector loop

* **Direct/open loop** - the water drains automatically when the sun isn't shining.

* **Batch** (*Integral collector/storage (ICS) system; aka* - "breadbox" water heater - appropriate for mild climates; it combines a collector and storage tank into one unit. Sun shining on the collector strikes the storage tank directly, heating the water. The water's large thermal mass, along with the insulation that reduces heat loss through the tank, prevents the stored water from freezing.

* **Thermosyphon**: Has a separate storage tank above the collector. Warm, less-dense liquid in the collector rises naturally above it and remains there until needed. As water cools in the tank, becoming more dense, it naturally sinks back down to the collector.

Active, Open-loop, Pumped Direct System
Example Configuration



- No freeze protection
- Minimal hard water tolerance
- High maintenance requirements

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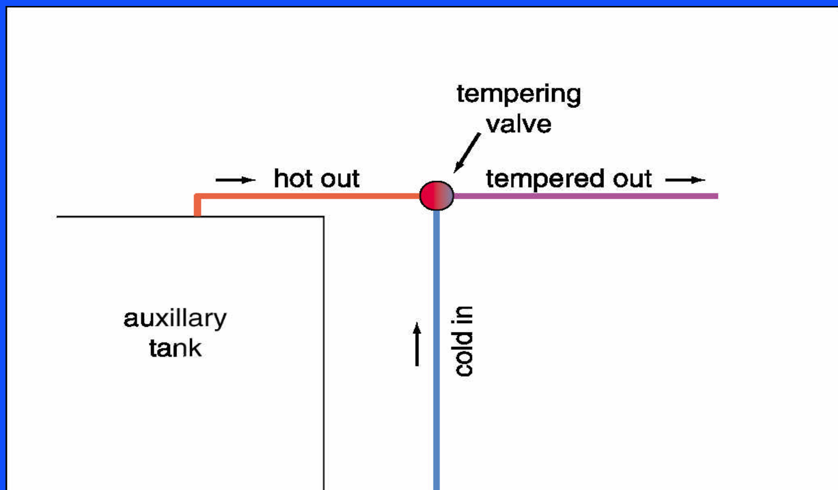
Tempering Valve to Prevent Scalding: Extremely Important for Safety!



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Cost-Effective
Solar Water Heating Applications

- Low temperature (unglazed collector)
  - Swimming Pools
- Mid temperature (flat plate)
  - Residential Hot Water
  - Cafeterias
  - Laundries
  - Air Conditioning “Reheat”
- High temperature (evacuated tube or parabolic trough)
  - Industrial Processes

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Solar thermal collectors can be categorized by the temperature at which they efficiently deliver heat.

Low-temperature collectors:

Unglazed mats for water heating.

Perforated plates for air preheating.

Mid-temperature collectors:

Glazed and insulated collectors.

High-temperature collectors:

Evacuated tubes.

Focusing collectors.

Pools - highest heat loss. Can use High Temp SHW system

Air Conditioning Reheat - to remove excess humidity. Cool, too condense out water, then need to reheat air since it gets too cold to use.

Electrical Generation - heats working fluid such as water, freon, etc

Criteria for Cost-Effective Applications

- Constant water heating loads
- High cost of backup energy
- Sufficient area to site collectors (1 ft^2/gal/day)
- Sunny climate helps but works in cold climates too
- Cost effective in Hawaii - hundreds of existing systems

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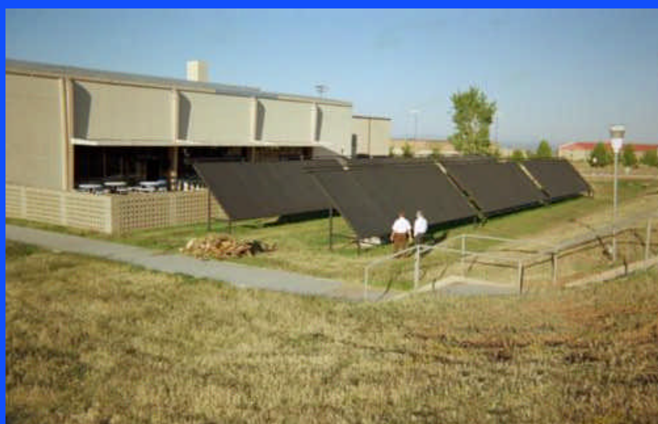
Constant water heating loads throughout week and year (or more in the summer).

High cost of backup energy - electricity, propane, etc

Navy Moanalua Terrace housing - 136 solar hot water systems. **[pix05573]**

Coast Guard Kiai Kai Hale Housing

Barnes Field House, Fort Huachuca, AZ
Low Temperature Example



- 2,000 square feet of unglazed collectors
- 3,500 square feet indoor pool
- Installed cost of $35,000
- Meets 49% of pool heating load
- Saves 835 million Btu/ year of natural gas
- Annual savings of $5,400
- Installed by the Army in June, 1980.

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USCG Kiai Kai Hale Housing Area, Honolulu

Mid Temperature Example

- 62 units installed 1998
- Active (pumped), Direct systems
- Average cost $4,000 per system
- 80 square feet per system
- $800 per system HECO rebate
- Savings of 9,700 kWh/year and $822/year per system
- Simple Payback 4 years (with rebate)

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EPA Lab, Edison NJ
High Temperature Example

- Three closed loop systems with evacuated tube collectors, heat exchanger in the preheat tank. Food-grade Propylene Glycol solution for freeze protection.
- Total Cost=$26,000
- 15 year payback

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Bay F 80 gallon preheat tank and 20 ft^2 of collector area.

Bay B 80 gallon preheat and 40 ft^2 of collector area

Bay D 120 gallon preheat tank and 90 ft^2 of collector area , measured output averaged 50,000 Btu/day in December, 98.

Phoenix Federal Correctional Institution
High Temperature Example

- 17,000 square feet
- 20,000 gallon storage tank
- Delivers 1,150,000 kWh/yr (~2/3 of the water heating load).
- Financed, Installed (1998) and Operated under Industrial Solar Technology ESPC
- Prison pays IST for energy delivered at rate equal to 90% of the utility rate (10% guaranteed savings)
- 20 year contract
- Agency saves 10% of energy costs - $7750 the first year.

Actually a mid-temperature application (hot water for showers, cafeteria, etc)

PV and Solar Hot Water Heating
Requirements for Success

- Energy Efficiency First
- Appropriate Application (Provide a Reasonable Payback)
- Proven Design
- Verify Load Estimates
- Properly Sized (undersized, not oversized)
- Require No Manual Intervention
- Operational Indicators or Monitoring
- Performance Guarantee
- Require Operations and Maintenance Manual and Training
- Acceptance Test

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Performance Guarantee - payment/kwh produced is example of good contract where costs dependent on equipment performance.

PV and Solar Hot Water Heating
Project Considerations

- Agencies should consider:
  - Size and nature of load
  - Availability of *unshaded* solar resource
  - Cost of alternative power sources

- Solar Issues and Challenges
  - Intermittent. Hybrid or storage may be required.
  - Cost
  - Limited domestic demand

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Hawaii probably has higher costs due to shipping costs

PV and Solar Hot Water Heating
See Appendix for…

- PV System Efficiency
- PV & SHW System Sizing and Design
- PV & SHW Cost Effectiveness Calculations
- Various Solar Hot Water System Configurations
- Solar Hot Water O&M Survey Results

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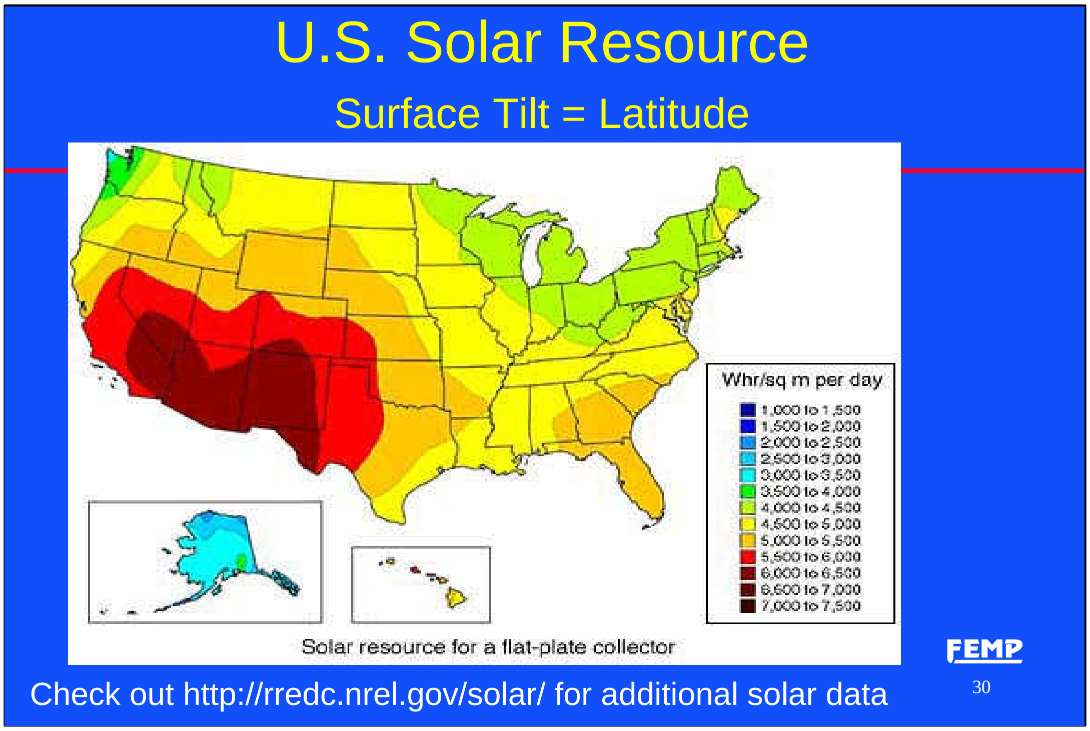


Unites are watt-hours/meter squared/day - amount of energy that actually hits earth. Only small portion is actually converted to electricity

Collectors should face south (in northern hemisphere)

Tilt Angle=latitude maximizes annual gain

-lat+15°for more energy in winter (ex. school that is closed in summer)

-lat-15° for more energy in summer (ex. park that is closed in winter)

Best resources - Oahu, Molokai, Lanai, western Maui.

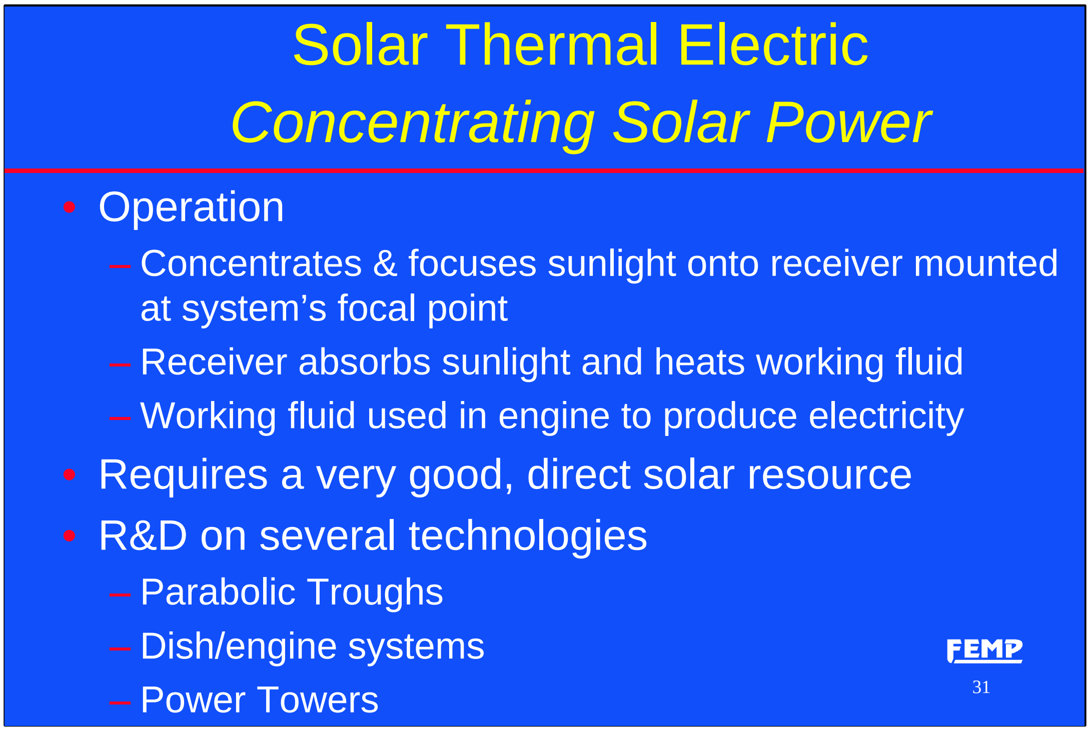
1 kw $_{ac}$ would produce 1800-2000 kwh/year (~20% capacity factor)

Location	**I Max**	**I Ave (kWh/m2/day)**
Honolulu, HI	**6.5**	**5.5**

“Rated Power” =PV output under std rating conditions (1 kW/m^2 light, 25 C, 1 m/s wind)

Example: 3.6 kWh/m^2/day = 3.6 “sun hours”/day at 1 kW/m^2

-A module “rated” at 50 W would produce 0.180 kWh in that day.



•Can only use DIRECT rays. Not reflected. Whereas flat plate can use reflected light off clouds or ground.

•Concentrating PV systems - record with over 30%.

Three types of technologies:

•Troughs: Rows of parallel mirrored troughs

•Dish/Engine: Parabolic shape that focuses on an receiver - whole thing tracks sun. Can be distributed.

•Power Towers. Mirrors track the sun and concentrate on central receiver tower - only for large-scale generation.

-Large test plant was deemed successful but not economic at present.

-10 MW near Barstow, CA (world's largest)

•Current technologies cost 9¢-12¢ per kilowatt-hour.

• Dispatchable - hybrid and/or thermal storage

•Usually used for large-scale applications. But also useful for small scale such as remote locations.

Concentrating Solar Power
Emerging Technologies

Dish/Engine System in
Golden, CO

Trough,
Mojave Desert, California

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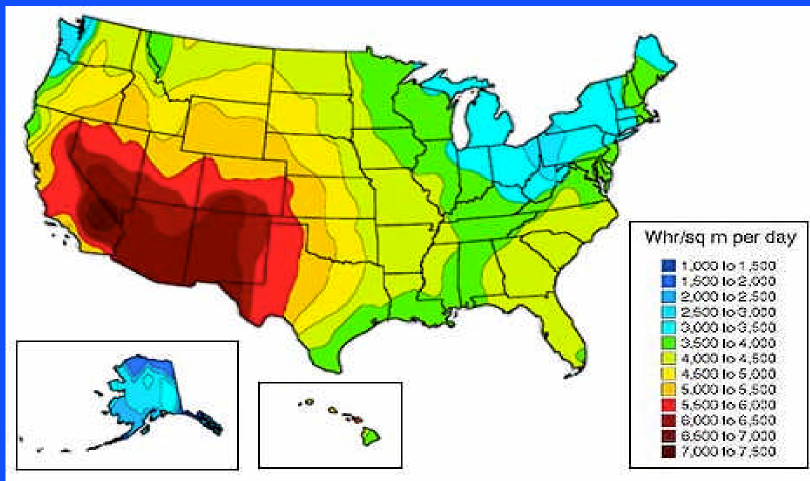
Dish/Engine - stirling engine
each dish is 7-25 kw

Trough: Luz International in S. CA. 354 MW - world's largest

U.S. Solar Resource

Concentrating Collector



Solar resource for a concentrating collector

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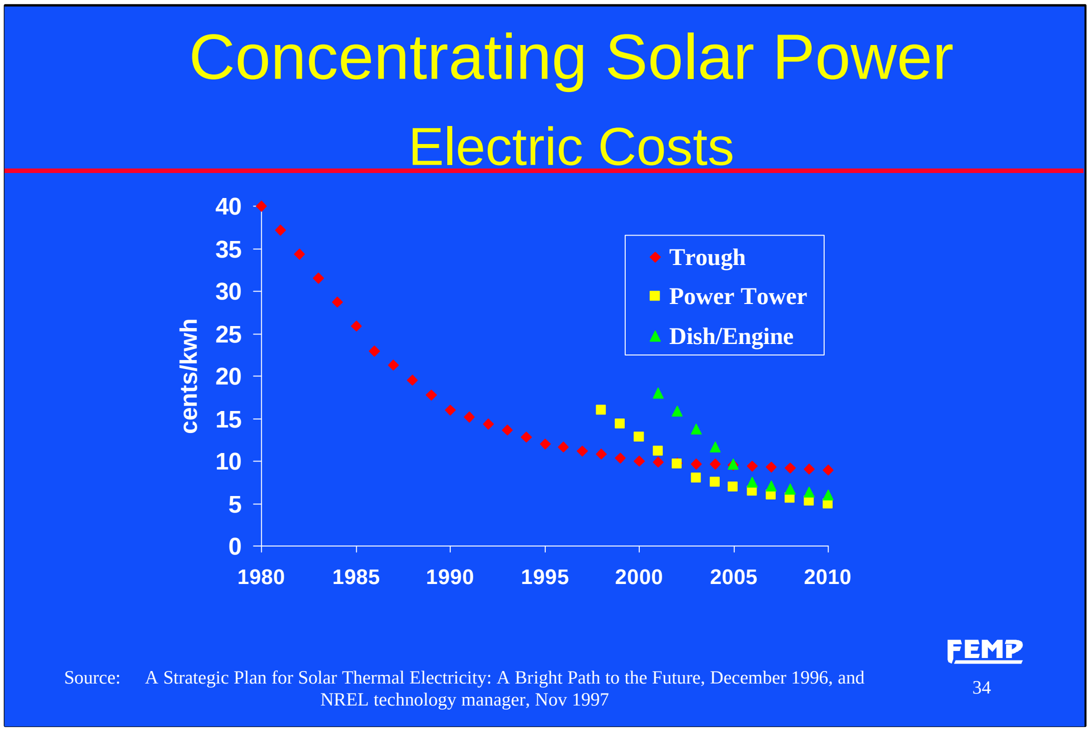
Best - Maui, Molokai, Lanai.

Hawaii not good enough resource

Different map since need direct rays (PV can use reflected/diffuse light)



Concentrating solar power technologies currently offer the lowest-cost solar electricity for large-scale power generation (10 megawatt-electric and above).

Current technologies cost $2-$3 per watt. This results in a cost of solar power of 9¢-12¢ per kilowatt-hour.

New innovative hybrid systems that combine large concentrating solar power plants with conventional natural gas combined cycle or coal plants can reduce costs to $1.5 per watt and drive the cost of solar power to below 8¢ per kilowatt hour.

Advancements in the technology and the use of low-cost thermal storage will allow future concentrating solar power plants to operate for more hours during the day and shift solar power generation to evening hours. Future advances are expected to allow solar power to be generated for 4¢-5¢ per kilowatt-hour in the next few decades.

Particularly - look at the dish/engine system which can be used as a distributed generation resource.

Solar Resources

- Key contacts:
  - **National Renewable Energy Laboratory**

    John Thornton: (303) 384-6469

    Andy Walker: (303) 384-7531
  - **Sandia National Laboratory**

    Hal Post: (505) 844-2154

    Mike Thomas: (505) 844-1548

- Federal Technology Alerts - PV, Solar Water Heating, Parabolic-Trough Solar Water Heating

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FTA’s - SHW and parabolic trough SHW

Solar Resources

- American Society of Heating, Air Conditioning and Refrigeration Engineers, Inc.
  - ASHRAE 90003 -- Active Solar Heating Design Manual
  - ASHRAE 90336 -- Guidance for Preparing Active Solar Heating Systems Operation and Maintenance Manuals
  - ASHRAE 90346 -- Active Solar Heating Systems Installation Manual
- Solar Rating and Certification Corporation
  - SRCC-OG-300-91 -- Operating Guidelines and Minimum Standards for Certifying Solar Water Heating Systems

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Solar Web Sites

- **GSA Federal Supply Schedule** - http://www.gsa.gov/regions/7fss/7fx/schedules
- **DOE Solar Sites** - http://www.eren.doe.gov/RE/solar.html, http://www.eren.doe.gov/millionroofs/
- **Solar Resource Maps** - http://rredc.nrel.gov/solar/
- **National Center for Photovoltaics** - http://www.nrel.gov/ncpv/
- **Florida Solar Energy Center (FSEC) -** http://www.fsec.ucf.edu/index.htm

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Solar Web Sites

- **Solar Energy Industries Association (SEIA)** - http://www.seia.org/main.htm
- **Solar Electric Power Association (formerly UPVG)** http://www.ttcorp.com/upvg/index.htm
- **TEAM-UP** - http://www.ttcorp.com/upvg/team_mn.htm
  Building Technology Experience to Accelerate Markets in Utility Photovoltaics. A utility industry and DOE partnership that provides cost-sharing for selected PV business ventures in the United States
- **Links to various solar sites** - http://www.ttcorp.com/upvg/pv_othr.htm

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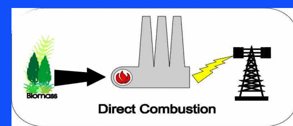
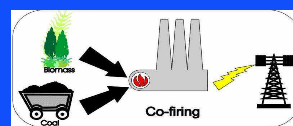
Biomass and Geothermal

Options for Biomass Electricity

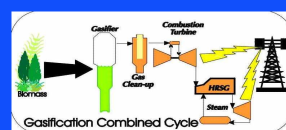
- Direct combustion -- 7500 MW installed in the U.S.



- Co-firing of wastes -- demonstration phase



- Gasification, pyrolysis -- under development



- Landfill Gas

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Resource primarily found in eastern U.S.

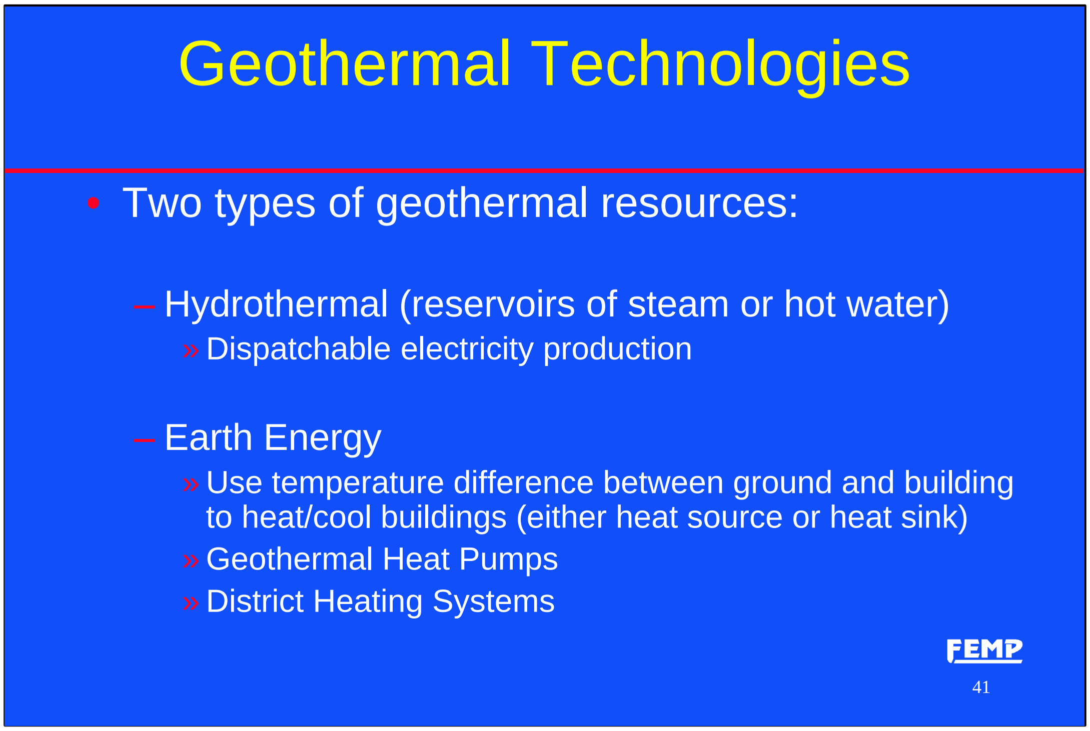
Hawaii resource primarily agricultural residues

Electric power from biomass is undergoing an exciting transformation.

Biomass Power is not new - Direct combustion of biomass already provides 7500 MW of capacity to the U.S. grid. But the efficiencies of this process are not very high.

Co-firing has emerged as one new option - where coal plant co-fires the coal process with biomass wastes. This can reduce certain emissions and can increase the types of coal a plant can use. There are already success projects demonstrating this technology option.

And under development right now is a new way of using biomass. This system - termed gasification - gasifies the biomass fuel and uses the gas to run and advance turbine. This opportunity to use biomass in a Combines Cycles electric plant is exciting. It has already been proven in small-scale design, and the first full-scale plant is under construction in Burlington, VT.

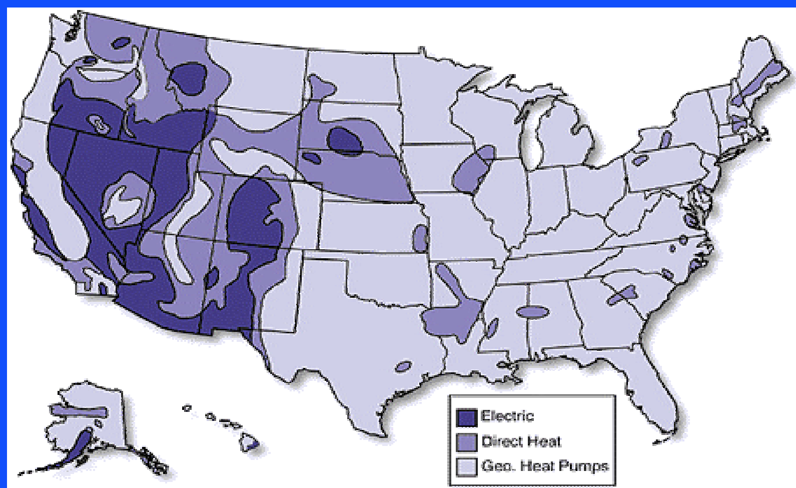


Two types of geothermal resources are being tapped commercially: hydrothermal fluid resources and earth energy. Hydrothermal fluid resources (reservoirs of steam or very hot water), are well-suited for electricity generation. Earth energy, the heat contained in soil and rocks at shallow depths, is excellent for direct use and geothermal heat pumps.

The hydrothermal resources are concentrated in the western U.S., Alaska and Hawaii.

The whole country has opportunities for geothermal heat pumps.

U.S. Geothermal Resource



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The Geysers

Biomass and Geothermal in Hawaii

- Sugar waste
  - Reduction in total due to sugar mill closures in Kauai (Lihue plantation) and Maui (Pioneer and Paia Mills)
- 3 MW landfill gas (HECO)
- 46 MW Municipal Solid Waster (HECO)
- 30 MW Geothermal (HELCO)

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Biomass in Hawaii - primarily agricultural waste, especially sugar.

Sugar

Kekaha - 7.5 MW

Olokele Sugar 4 MW

Hawaiin Commericail - Puunene Factory 52 MW

Closed

Lihue, Kauai - 25.8 MW

Maui Pioneer - 9.3 MW

Maui Paia Factory - 9 MW

Geothermal Heat Pumps

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Geothermal Heat Pumps

- Transfers heat to/from the ground below
- Three major components
  - Ground loop (buried piping system)
  - Heat pump
  - Heating/cooling distribution system

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GHP System Types

- Earth Coupled (Closed Loop)
  - Horizontal or vertical pipes

- Water Source (Open Loop)
  - Water pumped from well or other source to heat exchanger, then back to source

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Geothermal Heat Pump Benefits

- Lowest Life Cycle Cost
  - May be lower first cost
  - Lower O&M costs
- Reduced Utility Demand Charges
- Hot Water Heating - using waste heat from air conditioning

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Considerations in Hawaii

- Aquifer is a concern
  - Use horizontal vs. vertical wells
- Need environmental authorization and approval

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Geothermal Heat Pumps
See Appendix for…

- Cost Information
- System Design
- Equipment Selection

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Geothermal Heating and Cooling Information Resources

- Air Conditioning Refrigeration Institute (ARI) - industry ratings and standards:
  - ARI-320: Water Loop (boiler/tower) equipment.
  - ARI-325: Ground Water (open loop) equipment.
  - ARI-330: Ground Source (closed loop) equipment.
- Look for ARI proof of performance certification
- Geothermal Heat Pump Consortium
  - http://www.ghpc.org
  - (202) 508-5500

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Biomass and Geothermal Resources

- **DOE Bioenergy Site - http://www.eren.doe.gov/RE/bioenergy.html**
- **DOE Geothermal Sites** -
  http://www.eren.doe.gov/RE/geothermal.html
  http://www.eren.doe.gov/geopoweringthewest/
- **FEMP Geothermal Heat Pump ESPC -**
  http://www.eren.doe.gov/femp/financing/tecspec.html#ghp

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Whole Building Integrated Design

WBID - also known as sustainable design, low energy design

Whole Building Integrated Design

- Optimize performance of entire building, rather than selecting components one by one according to their individual capacity to save energy.
- Low energy design - typical savings can be 40-70% of the energy use over conventional base case
- On average, no increase in construction cost

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Optimize performance of a combination of potential products, systems and design rather than selecting components one by one according to their individual capacity to save energy.

Considerations

- Building siting
  - Overall climate
  - Orientation
- Building Envelope
  - Adequate insulation
  - Low air leakage

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Considerations

- Windows
  - Balance light vs. heat gain
  - Locations
  - Size
  - Glazing
  - Overhangs

- Thermal Mass
  - Walls and floors serve as heat storage

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Process Tips

- Begin in the predesign phase
- Use a collaborative, interactive approach
- Understand the energy implications of the building form, organization and its internal operations
- Establish low energy and sustainable design goals for the building
- Site and orient the building to respond to local climatic conditions, natural landscaping and nearby services

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Process Tips

- Select contractors and A/Es for the demonstrated experience in low-energy design and construction
- Conduct energy performance and lighting analysis using tools that account for interactions to optimize design
- Specify “green building” materials
- Commission equipment and controls.
- Educate the building operator

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Whole Building Integrated Design
See Appendix for…

- Architects and Engineers Selection
- Analysis Tools
- Natural Ventilation
- Daylighting
- Glazing
- Shading

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Whole Building Integrated Design Energy Software Packages

- ASEAM - Advance Sciences Inc, 703-243-4900
- BLAST - BLAST Support Office, 217-333-3977
- Building Design Advisor - LBNL, 510-486-4000
- DOE-2 - LBNL, 510-486-4000
- Energy 10 - Passive Solar Industries Council, 202-628-7400 ext 210
- Energy Scheming - Univ. of Oregon, 503-346-3656
- Hourly Analysis Program (HAP) - Carrier Corp, 315-432-7072
- TRACE - The Trane Company, 608-787-3926

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Whole Building Integrated Design Resources

- Andy Walker, NREL, 303-384-7531
- **FEMP Courses**

  Designing Low-Energy, Sustainable Buildings
  http://www.eren.doe.gov/femp/resources/training/fy2001_low_energy.html

  Laboratories for the 21st Century
  http://www.eren.doe.gov/femp/resources/training/fy2001_labs.html

- **Whole Building Design Guide** - http://wbdg.org/

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Labs for 21st Century

- Nancy Carlisle, LBNL

- jointly sponsored by DOE and EPA

Whole Building Integrated Design Resources

- **Sustainable Buildings Industry Council (SBIC)**
  202-628-7400, www.SBICouncil.org

- **Leadership in Energy and Environmental Design (LEED) - Green Building Rating System**
  -U.S. Green Building Council
  -Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality
  -http://www.usgbc.org/

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Hawaii Renewable Energy Research

- Renewable Energy Resource Assessment and Development Program
  - Completed by GEC in 1995 as part of the Hawaii Energy Strategy
  - Identified potential sites for renewable energy projects in Hawaii
  - Collected wind and solar resource data
  - Developed cost and performance estimates for each potential project
- Additional Research for Renewable Portfolio Standard (RPS) Proceedings

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Why Hawaii Should Increase the Use of Renewable Energy for Electricity

- Reduced cost of fuel for electricity generation
- Reduced reliance on imported oil and volatile oil prices
- Reduced risk through diversification of electricity generation options
- Job creation and economic benefits
- Environmental benefits
  - Reduced risks of water and soil contamination from oil spills
  - Better air quality
  - Reduction of greenhouse gas emissions and risks to Hawaii from Global Climate Change

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July 2000 - Hawaii paid $33.50/barrel compared to $27.50 for rest of US (21% more)

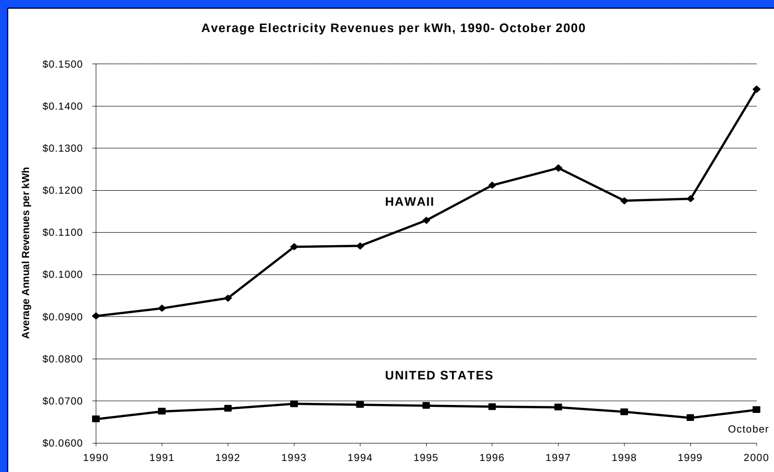
Climate Change

Honolulu +4.4 degrees average temp in last century

rainfall decreased by 20% in past 90 years.

6-14 inches increase in sea level this century. 17-25 inches increase forecasted by 2100 - flooding, contamination of drinking water, beach erosion, etc.

The Cost of Electricity in Hawaii is Growing Rapidly



The electricity needed by Hawaii's businesses, citizens, and visitors comes at a premium cost. Hawaii's average statewide electricity revenues per kWh were the highest in the nation as of October 2000. The average revenue per kWh in the United States was $0.0679. In Hawaii, average revenues per kWh were $0.144 -- over twice the U.S. average.

Not only were Hawaii's electricity revenues per kWh the highest in the nation in October 2000, electricity revenues per kWh for Hawaii utilities (nominal dollars) grew much faster than the U.S. average over the years since 1990. Hawaii's revenues per kWh were 59.6% higher while the U.S. average was only 5.2% higher. For comparison, Honolulu consumer prices increased about 25.5% from 1990 to 1999 (later data not available).

Hawaii's Renewable Energy Usage Existing and Forecast

Estimated Percentages of Utility Electricity Sales from Existing Renewable Energy Resources			
Utility	**1999**	**2001**	**2010**
HECO	4.4%	4.1%	3.6%
HELCO	26.1%	28.3%	24.1%
KE	13.9%	7.5%	5.6%
MECO	4.7%	4.7%	3.7%
Statewide	7.2%	6.6%	5.7%

In 1999, renewable energy produced 7.2% of the electricity generated for sale by the four electric utilities. Renewable energy generation capacity was reduced in 2000 by the closure of Lihue Plantation on Kauai and Pioneer and Paia Mills on Maui. If the remaining renewable energy resources in operation at the end of 2000 continue in operation through 2010, they will provide an estimated 642 GWh of sales during each year of the period. This will amount to approximately 6.6% of total electricity sales in 2001. As electricity demand grows, the percentage of electricity sales from renewable resources will decline to approximately 5.7% statewide by 2010.

Note: The 2001 increase in HELCO's renewable percentage is because HELCO's forecast for 2001, made in 1997, is lower than actual sales were in 1999.

Cost of Energy – Current Projects (2000)

Technology	Island	Location	Capacity MW	COE $/kWh
Geothermal	Hawaii	Kilauea	8	$0.045
Hydroelectric	Hawaii	Umauma Stream	13.8	$0.076
	Kauai	Wailua River	6.6	$0.093
Photovoltaics	Hawaii	N Kohola	5	$0.298
	Oahu	Pearl Harbor	5	$0.305
Wind	Hawaii	Kahua Ranch	10	$0.055
		Lalamilo Wells	3	$0.044
		Lalamilo Wells	30	$0.046
		Lalamilo Wells	50	$0.044
		North Kohala	5	$0.043
		North Kohala	15	$0.043
	Kauai	N. Hanapepe	10	$0.067
		Port Allen	5	$0.073
	Maui	McGregor Point	20	$0.051
		NW Haleakala	10	$0.055
		NW Haleakala	30	$0.064
		NW Haleakala	50	$0.061
		Puunene	10	$0.077
		Puunene	30	$0.083
	Oahu	Kaena Point	3	$0.068
		Kaena Point	15	$0.070
		Kahuku	30	$0.067
		Kahuku	50	$0.059
		Kahuku	80	$0.069

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Summary of Hawaii Renewable Opportunities

- Significant costs and performance improvements achieved since 1995
- Additional experience and deployment of renewable technologies worldwide
- Wind and geothermal offer least cost
- Opportunities exist on all islands

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Thousands of Cost-Competitive Renewable Energy Systems in the Federal Government *(as of 3/99)*

- **Over 1000 SWH systems installed in Federal sites in Hawaii**
- 4.1 MW (over 2000 systems) of PV in DoD
- 70,000 Mwh of energy from geothermal heat pumps
- 1.79 MW wind in DoD
- 600 small PV systems in National Park Service
- 500 small PV systems in U.S. Forest Service
- 215 small PV systems in Bureau of Land Management
- 16,500 Coast Guard navigational aids with PV systems
- Hundreds of passive solar buildings in the U.S. Postal Service, General Services Administration and Department of Interior.

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Additional Resources

- Cost-Effectiveness Calculations
  - Life cycle cost effectiveness (LCC)
  - Savings to investment ratio (SIR)
  - Years to payback
  - Payback Period = Installed Cost/(First year fuel expense savings - annual O&M cost)
- ***See Appendix for details***

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"Building Life-Cycle Cost" (BLCC) computer program NIST 4481:

http://www.eren.doe.gov/femp/techassist/softwaretools/softwaretools.html#blcc

Life-cycle Costing Manual for the Federal Energy Management Program, NIST Handbook Number 135:

Required assumptions and procedures.

Instructions for calculating required indicators.

"Energy Prices and Discount Factors for Life-Cycle Cost Analysis" NISTIR 85-3273, updated annually:

Required discount rates.

Fuel escalation rates by census region.

Workshops: For a schedule contact Office of Applied Economics, NIST, Building 226, Room B226, Gaithersburg, MD 20899.
Phone: (301) 975-6132.

Telecourse (2 hours), course (2 days)

http://www.eren.doe.gov/femp/resources/training/fy2001_lifecycle_cost.html

http://www.eren.doe.gov/femp/resources/training/fy2001_lifecycle2.html

Videos: "Introduction to Life-Cycle Costing," "Choosing Economic Evaluation Methods," and "Uncertainty and Risk" from Video Transfer, Inc., 5709-B Arundel Ave., Rockville, MD 20852. *Phone:* (301) 881-0270.

Additional Resources

- **Federal Renewable Energy Screening Assistant (FRESA)**
  - Software tool to facilitate renewable energy opportunity assessments
  - Download from FEMP Web Site
    http://www.eren.doe.gov/femp/techassist/softwaretools/softwaretools.html#fresa
- **FEMP "Implementing Renewable Energy Projects" Course**
  http://www.eren.doe.gov/femp/resources/training/fy2001_implement.html
- **Distributed Energy Resources (DER) Call for Projects**
  - Applications were due March 16
- **Renewable Project Funding**

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Additional Resources

- **Hawaii-Specific Energy Information**
  http://www.eren.doe.gov/state_energy/mystate.cfm?state=hi
- **State of Hawaii Renewables Site**
  http://www.hawaii.gov/dbedt/ert/renewable.html
- **NREL Web Site** - http://www.nrel.gov
- **NREL Renewable Resource Data Center** - http://rredc.nrel.gov/
- **FEMP Renewables Site**-
  http://www.eren.doe.gov/femp/techassist/renewenergy.html
- **To Order FEMP Materials**
  800-363-3732 or http://www.eren.doe.gov/femp/ordermaterials.html

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